Echo in ICU and OR, including TEE

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UTHSCSA and STVHCS

The availability of TEE should in NO WAY adversely influence TTE technical quality

On-Call Echocardiography

- At UH – call the technician in
  - Do it yourself in certain situations
- At the VA – no technician on call
  - Do it yourself in all situations
- In the OR – often best to have technician available – bring your own videotape

Echo in the Operating Room

- Essentially always TEE
- Evaluation of ventricular function
  - LV filling: semiquantitative
    - LA pressure – MR peak velocity, LVIT and pulmonary venous Doppler
    - LVEDV and LVESV or area
  - LV systolic function
    - Cardiac Output
    - EF and stroke volume
  - Regional wall motion
  - Coronary reserve
- Great vessel – aortic dissection

Otto, 2nd ed. 2002. Ch. 2 Oxorn DC.

Echo in the SICU

- Often TEE after inadequate or confusing echo
- Hypotension or hypoxemia
  - LV dysfunction
  - Pericardial constriction/tamponade (localized)
  - Hypovolemia/aortic dissection-rupture
  - Pulmonary embolism
  - (Severe valve disease)

Echo in the MICU/CCU

- Often TEE after inadequate or confusing echo
- Hypotension or hypoxemia
  - LV dysfunction
  - Pericardial constriction/tamponade (localized)
  - Hypovolemia/aortic dissection-rupture
  - Pulmonary embolism
  - (Severe valve disease)
  - Sepsis

Table 1. Doppler Echocardiography Capabilities in the Adult Patient

Usefulness and Limitations

	Echocardiography		Spectral Doppler	Color Doppler	TEE
	M mode	2 D			
Anatomy-Pathology					
Chamber size	++++	++++	–	–	++
Thickness of walls	++++	+++	–	–	+++
Relation of chambers	+	++++	–	–	+++
Early closure of MV	++++	+	–	–	+
Systolic anterior motion of MV	++++	+++	–	–	+++
LV mass (g)	++++	++++	–	–	–
LV masses (tumor, clot, vegetation)	+	+++	–	–	++++
Masses in atria and right ventricle	+	++	–	–	++++
Anatomic valvular pathology	++	++++	–	–	++++
Septal defects	+	++++*	++	++++	++++
Pericardial effusion	++	++++	–	–	++
Function					
Global LV systolic function (EF)	++	++++	++	–	+++
Regional wall motion	+	+++	–	–	++++
Severity of valve stenosis	+	++	++++	+++	++
Severity of valve regurgitation	+	+	+++	+++	+++
Site of left-to-right, right-to-left shunt	–	+++* (together)	+++	++++ (together)	+++
RV and PA systolic pressure	–	–	++++	–	–
LV filling pressure	–	–	++	–	–
Stroke volume and cardiac output	+	++ (together)	+++	–	–
LV diastolic function	+	+	+++	–	–
Identify ischemia and viable myocardium with exercise or pharmacological stress	–	+++	–	–	–
Diseases of the aorta	–	++	–	++	++++
Prosthetic valve evaluation	+	++	++++	+++	++++

++++ indicates most helpful; +, least useful; –, not useful; 2D, two-dimensional; EF, ejection fraction; LV, left ventricular; MV, mitral valve; PA, pulmonary artery; RV, right ventricular; TEE, transesophageal echocardiography.

*With contrast (intravenous injection of agitated saline).

If TTE inadequate, TEE usually obtains desired information.

ACC/AHA Practice Guideline, Echo 2003; p. 6.

Advantages of TEE over TTE

- Better image quality, higher carrying frequency
  - Visualization of small structures (mass, tumor)
  - Visualization of left atrial (LAA) and valvular structures
  - Visualization of LA in MV prosthesis
  - Visualization of IAS, descending thoracic aorta and arch
  - Useful in patients with technically difficult TTE
  - Useful to monitor cardiac status and volume status and operative results in patients during thoracic surgery

Limitations of TEE Compared to TTE

- Windows limited to different esophageal levels and transgastric window (less uniformly helpful)
  - Doppler gradients may be falsely low
- Higher risk of complications
- Greater discomfort
- More expensive
  - Procedure
  - Equipment
  - Personnel (RN and physician in attendance)
  - Time

Indications for TEE

- Endocarditis and valvular disease
- Dyspnea, edema, and cardiomegaly
- Cardioembolic source
- Pre cardioversion
- Critically ill patients
- Imaging coronary ostia in congenital heart disease

ACC/AHA Practice Guideline, Echo 2003.

Indications for TEE in Endocarditis

- "In most cases TEE is not indicated as the initial examination in the diagnosis of native valve endocarditis"
- TEE is indicated (Class I) when
  - TTE is diagnostically inadequate due to poor technical quality or windows
  - TTE is negative in setting of high clinical suspicion
  - Prosthetic cardiac valve (TEE may provide incremental value)
  - High suspicion such as Staphylococcal bacteremia or fungemia (If TTE is equivocal)
  - Elderly patient with underlying valvular abnormalities that make diagnosis difficult
  - "TEE may frequently provide incremental value in addition to information obtained by TEE. The role of TEE in first-line examination awaits further study"
- Persistent nonstaphylococcal bacteremia without source (IIa)
- Risk stratification in established endocarditis (IIa)

ACC/AHA Practice Guideline, Echo 2003; p. 11.

Indications for TEE in Valvular Heart Disease

- Native valve disease or mitral valve prolapse – no indication for TEE as initial test
- For intervention (Echo indication is Class I):
  - For selection of alternative therapies for MS/MR (valvuloplasty, repair, replacement)*
  - Guiding performance of valvuloplasty, repair or replacement*
  - Suspected prosthetic valve dysfunction (changing signs and symptoms)*

*TEE may provide incremental value in addition to TTE
ACC/AHA Practice Guideline, Echo 2003; p. 13-4.

TEE in Dyspnea, Edema, or Cardiomegaly

- When TTE is nondiagnostic
  - Clinical diagnosis of HF or suspected DCM – for LV size and function
  - Edema and clinical signs of elevated CVP and clinical suspicion of heart disease is high
  - Unexplained hypotension, especially in Intensive Care setting
  - Pulmonary emboli and suspected clots in PA, RA or RV (IIa)

ACC/AHA Practice Guideline, Echo 2003; p. 39, 43.

Table 13. Transthoracic Versus Transesophageal Echocardiography for Detection of Potential Cardioembolic Source

Diagnosis by TTE*	Diagnosis by TEE (primarily or alone)
Mitral stenosis	Left atrial thrombus
Dilated cardiomyopathy	Left atrial spontaneous contrast
Left ventricular aneurysm	Atrial septal aneurysm
Left ventricular thrombus	Patent foramen ovale
Mitral valve prolapse	Aortic atheroma
Vegetation	
Atrial septal defect	

TEE indicates transesophageal echocardiography; TTE, transthoracic echocardiography.

*TTE is sufficient; TEE may be additive but not essential. "TTE sufficient" identifies disease entities for which TTE is sufficient to establish a diagnosis and for which TEE is unlikely to provide additional information. When detected with TTE, further evaluation by TEE is not necessary in all patients. "TEE additive" identifies entities for which documented incremental diagnostic yield can be obtained by performing TEE after negative TTE or entities for which the likelihood of unique TEE-identified abnormalities is high enough to warrant TEE even after adequate TTE.

ACC/AHA Practice Guideline, Echo 2003; p. 46.

Class I Indications for TEE in Anticipation of Cardioversion

- Urgent cardioversion where extended precardioversion anticoagulation is undesirable
- Prior cardioembolic events related to intra-atrial thrombus
- Anticoagulation is contraindicated and decision about cardioversion will be affected by TEE results
- Intra-atrial thrombus by prior TEE
- AFib of <48 hr but other heart disease (IIa)
- AFib of <48 hr and no other heart disease (IIb)

ACC/AHA Practice Guideline, Echo 2003; p. 49, 51.

Conditions and Settings in Which TEE Provides the Most Definitive Diagnosis in the Critically Ill and Injured

- The hemodynamically unstable patient with suboptimal TTE images
- The hemodynamically unstable patient on a ventilator
- Major trauma or postoperative patients (unable to be positioned for adequate TTE)
- Suspected aortic dissection Class I
- Suspected aortic injury Class I
- Other conditions in which TEE is superior (see section on valvular disease)

ACC/AHA Practice Guideline, Echo 2003; p. 59.

Preparation for TEE Examination

- Patient preparation
  - Contraindications: Esophageal pathology (stricture, varices, tumors, diverticula, scleroderma), severe atlantoaxial joint disease, prior XRT to chest, perforated viscus; hemodynamic instability, respiratory compromise
  - Fasting 4-6 h (urgent: only clear fluids for 2 hr*); obtain hx of prior endoscopy or gastroesophageal sx; IV access; suction; crash cart; monitor; O2, pulse oximeter
- Local anesthesia peak effect 2-5 minutes
  - Gargle 2% viscous xylocaine
  - 10% Cetacaine spray
  - NPO for at least 30 minutes after procedure

Weyman AE. Principles and Practice of Echocardiography, 2nd ed. 1994; p. 332

Preparation for TEE Examination - 2

- Anticholinergic is optional
  - Atropine 0.5 mg SQ or Glycopyrrolate (Robinul) 0.1-0.2 mg
  - Blurred vision so no driving, increase HR
- Sedation and Analgesia
  - Midazolam 0.5-5.0 mg (initial dose ≤2 mg IV over 1-2 min, 0.05 mg/kg)) or Diazepam 5-10 mg IV
  - Meperidine with acetaminophen or morphine can be used for associated discomfort
- Antibiotics for endocarditis prophylaxis are debatable, many laboratories use with prosthetic valves or intracardiac prostheses, poor dentition or prior endocarditis, Otto says no

Weyman AE. Principles and Practice of Echocardiography, 2nd ed. 1994; p. 332

Technique of TEE Examination

- Patient left lateral decubitus position
- Neck gently flexed; a bite guard should always be used except in edentulous patients*
- Index or index and middle fingers of nondominant hand advanced to base of tongue
- Probe advanced with dominant hand and passed beneath the index finger and guided using gentle downward pressure toward the mouth of the esophagus (manually depressing the back of the tongue provides more room, allowing the TEE probe to assume a less acute angle*)
- Anticipate transient gagging

Weyman AE Text 1994; p. 333

*Otto CM. The Practice of Echocardiography, 2nd ed. P. 3.

Technique of TEE Examination - 2

- With tip of probe at esophageal inlet (about 17 cm), patient is requested to swallow
- Once the patient begins to swallow, the probe should be advanced firmly but without force
- If resistance is encountered the probe should be readjusted or redirected centrally
- Rapid initial advancement to the carina or to more than 25 cm from incisors is essential (GE junction is usually at about 40 cm*)
- Rate of failure of probe introduction is 1.5-1.9%
- With difficult intubation a laryngoscope may be used to assist in passing the endoscope
- In intubated patients (i.e. OR or ICU) supine intubation is no problem, shift ET tube to one side; typically esophageal catheters are removed (or not*) to prevent kinking or knotting or intertwining, or obscuring vision

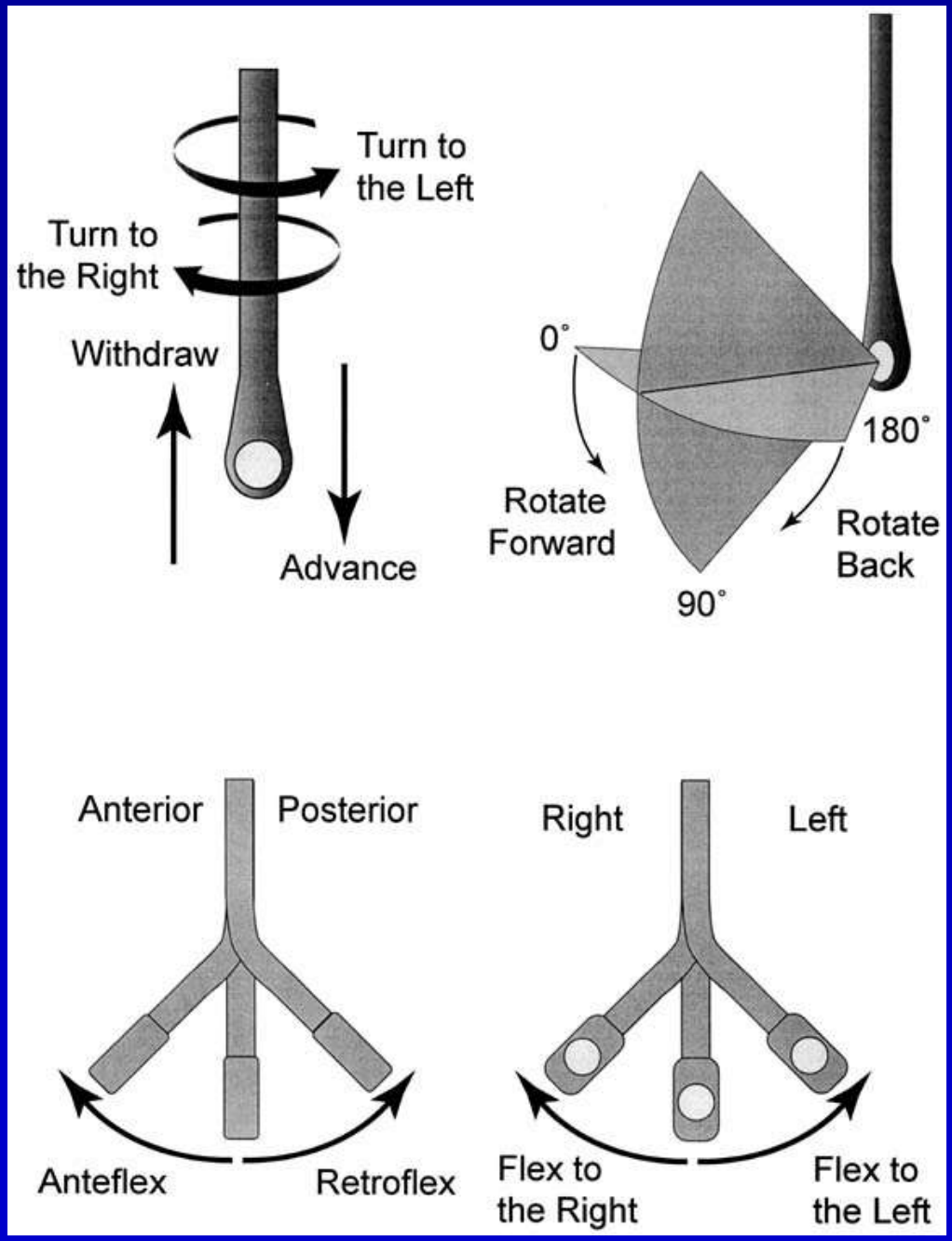
Weyman AE Text 1994; p. 333

*Otto CM. The Practice of Echocardiography, 2nd ed. P. 3.

Other Techniques of Intubation

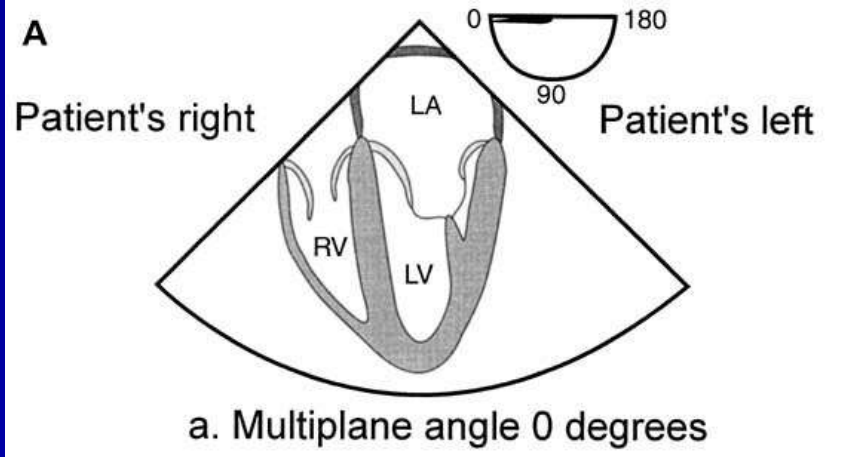
- Minimize visual exposure of the patient to the probe
- Bite block – necessary if patient not edentulous “I am putting something in your mouth that you can rest your teeth on.”
- If at first you don’t succeed, recheck patient position and anatomic geometry
- Ensure adequate local anesthesia
- Consider more sedation
- Remain gentle and kind
- As soon as you are in the esophagus, remind the patient to focus on breathing, “slow, deep breaths”

TEE Probe Manipulation

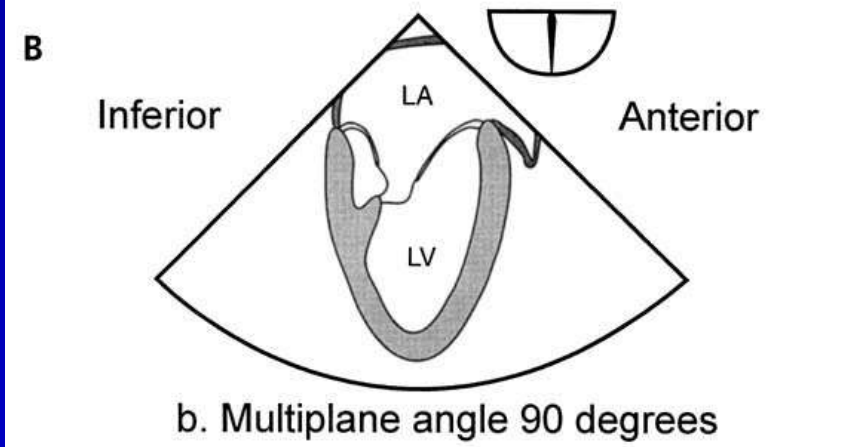


Shanewise JS et al. ASE/SCA Guideline Intraop TEE. J Am Soc Echocardiogr. 1999;12:884

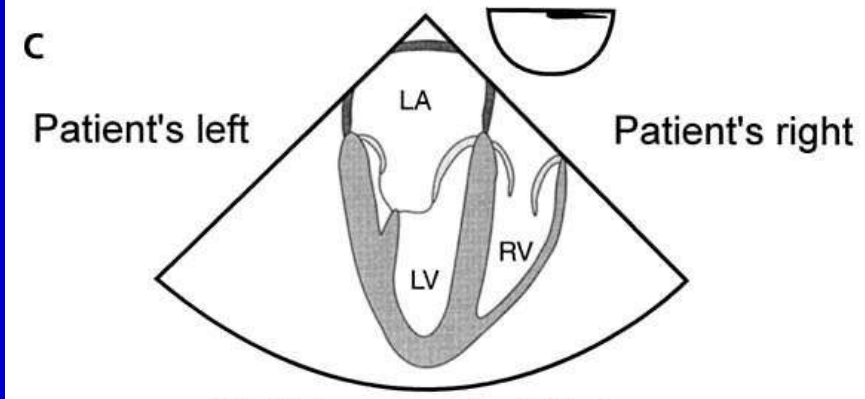
TEE Ventricular Views



a. Multiplane angle 0 degrees



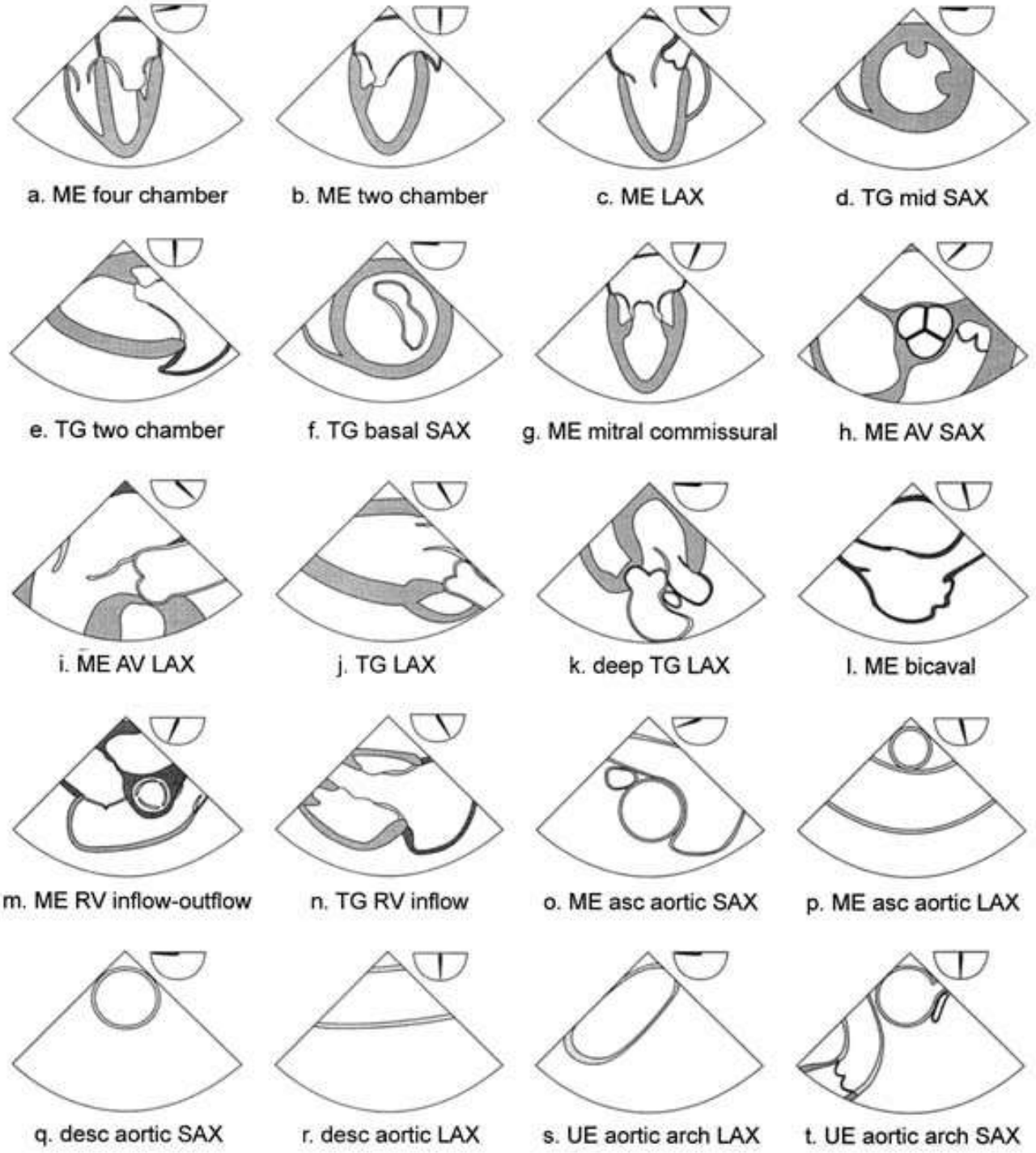
b. Multiplane angle 90 degrees



c. Multiplane angle 180 degrees

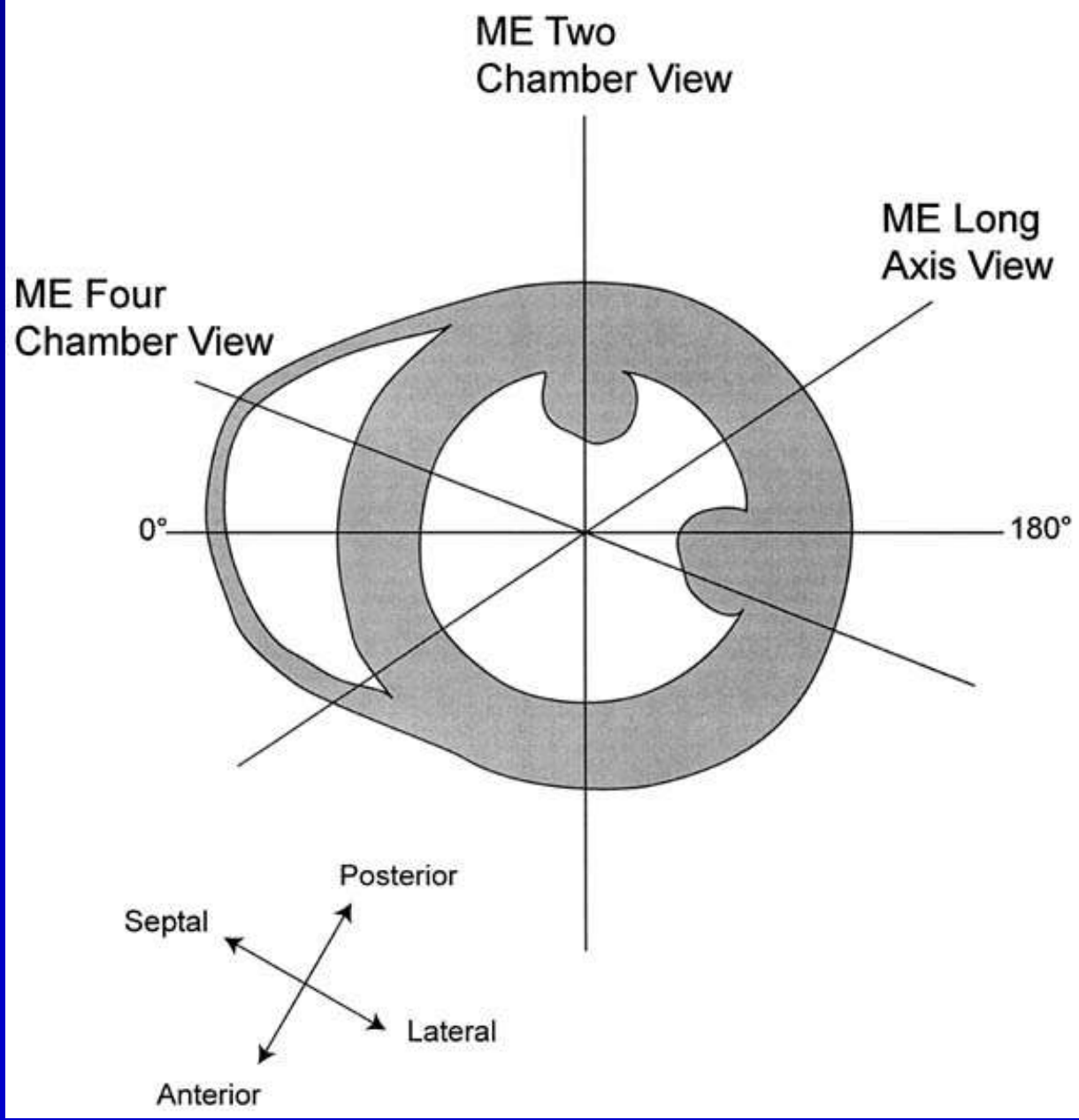
Shanewise JS et al. ASE/SCA Guideline Intraop TEE. J Am Soc Echocardiogr. 1999;12:884

TEE Views



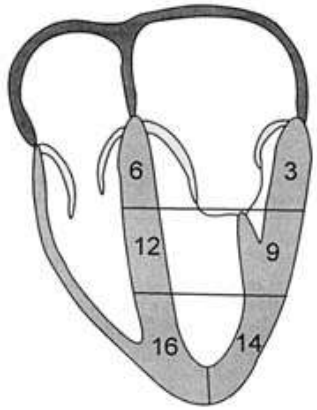
Shanewise JS et al. ASE/SCA Guideline Intraop TEE. J Am Soc Echocardiogr. 1999;12:884

TEE Views in Reference to Short Axis

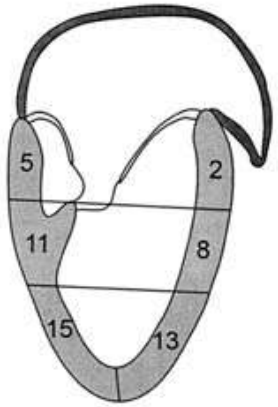


Shanewise JS et al. ASE/SCA Guideline Intraop TEE. J Am Soc Echocardiogr. 1999;12:884

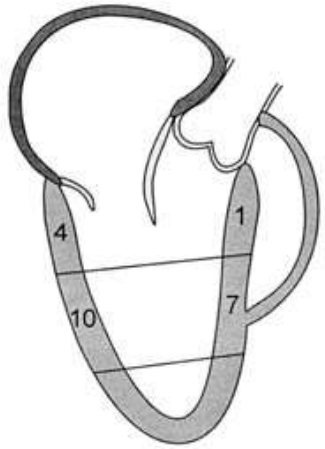
TEE Views in Reference to LV Segments



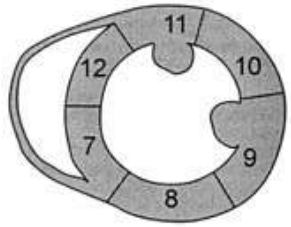
a. four chamber view



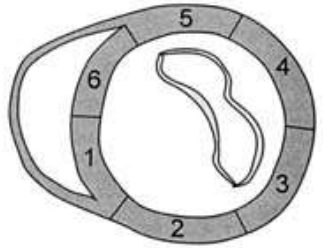
b. two chamber view



c. long axis view



d. mid short axis view

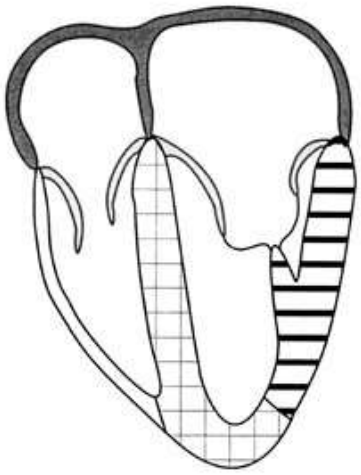


e. basal short axis view

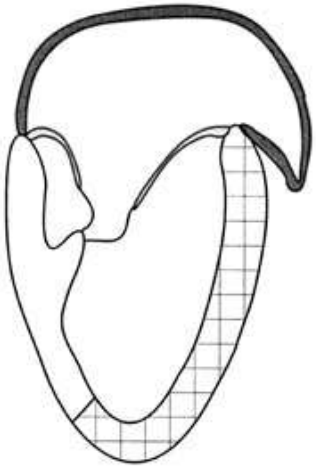
Basal Segments	Mid Segments	Apical Segments
1= Basal Anteroseptal	7= Mid Anteroseptal	13= Apical Anterior
2= Basal Anterior	8= Mid Anterior	14= Apical Lateral
3= Basal Lateral	9= Mid Lateral	15= Apical Inferior
4= Basal Posterior	10= Mid Posterior	16= Apical Septal
5= Basal Inferior	11= Mid Inferior	
6= Basal Septal	12= Mid Septal	

Shanewise JS et al. ASE/SCA Guideline Intraop TEE. J Am Soc Echocardiogr. 1999;12:884

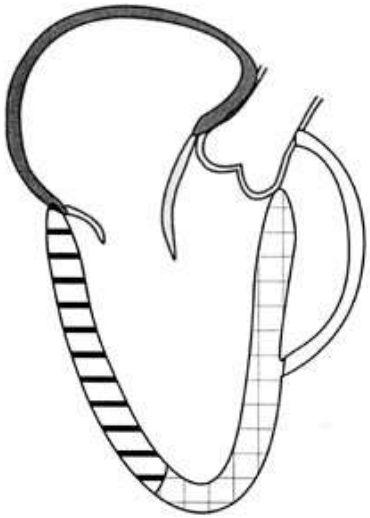
TEE Views and Coronary Distribution



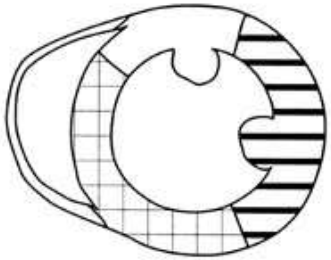
four chamber view



two chamber view



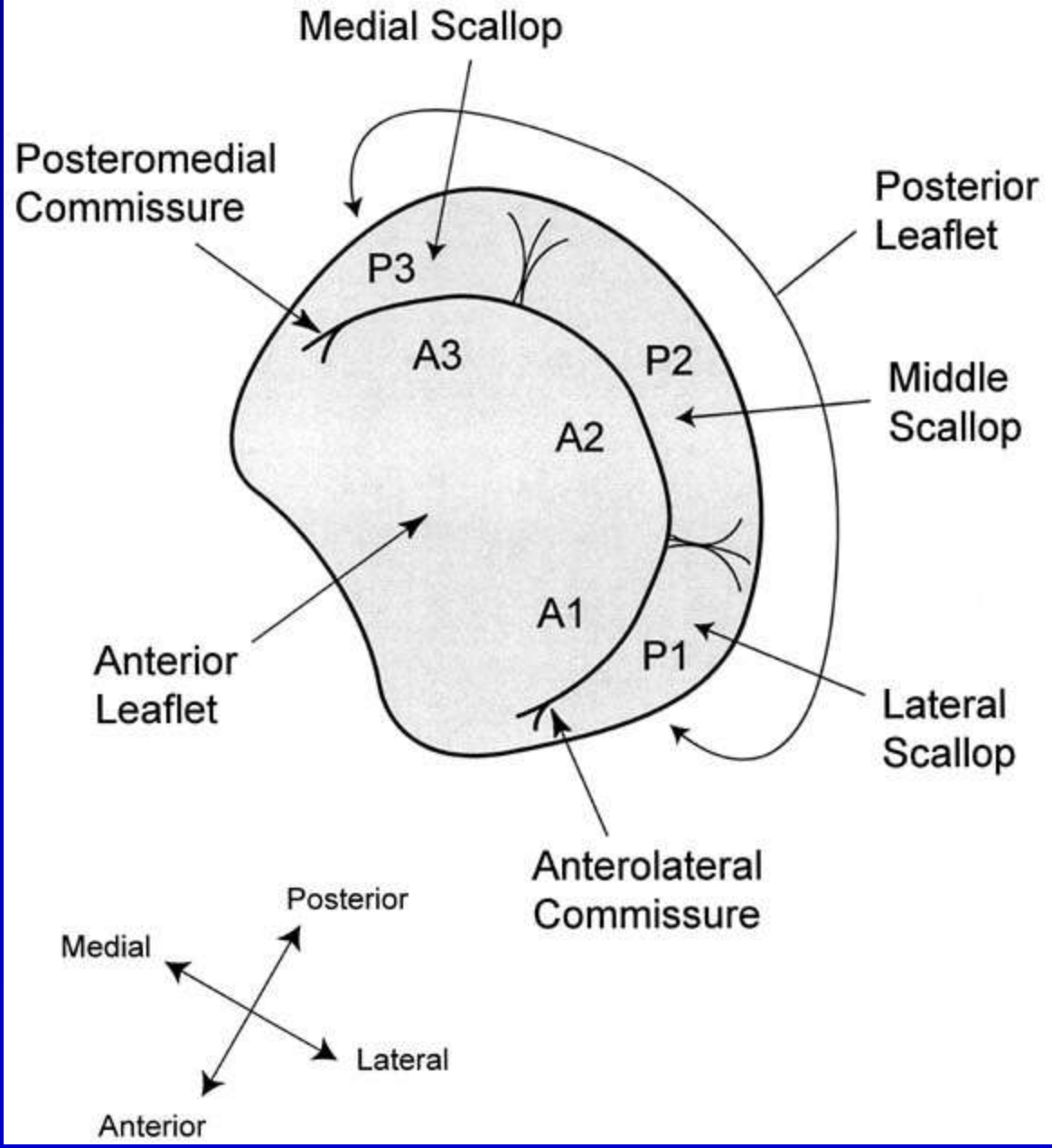
long axis view



mid short axis view

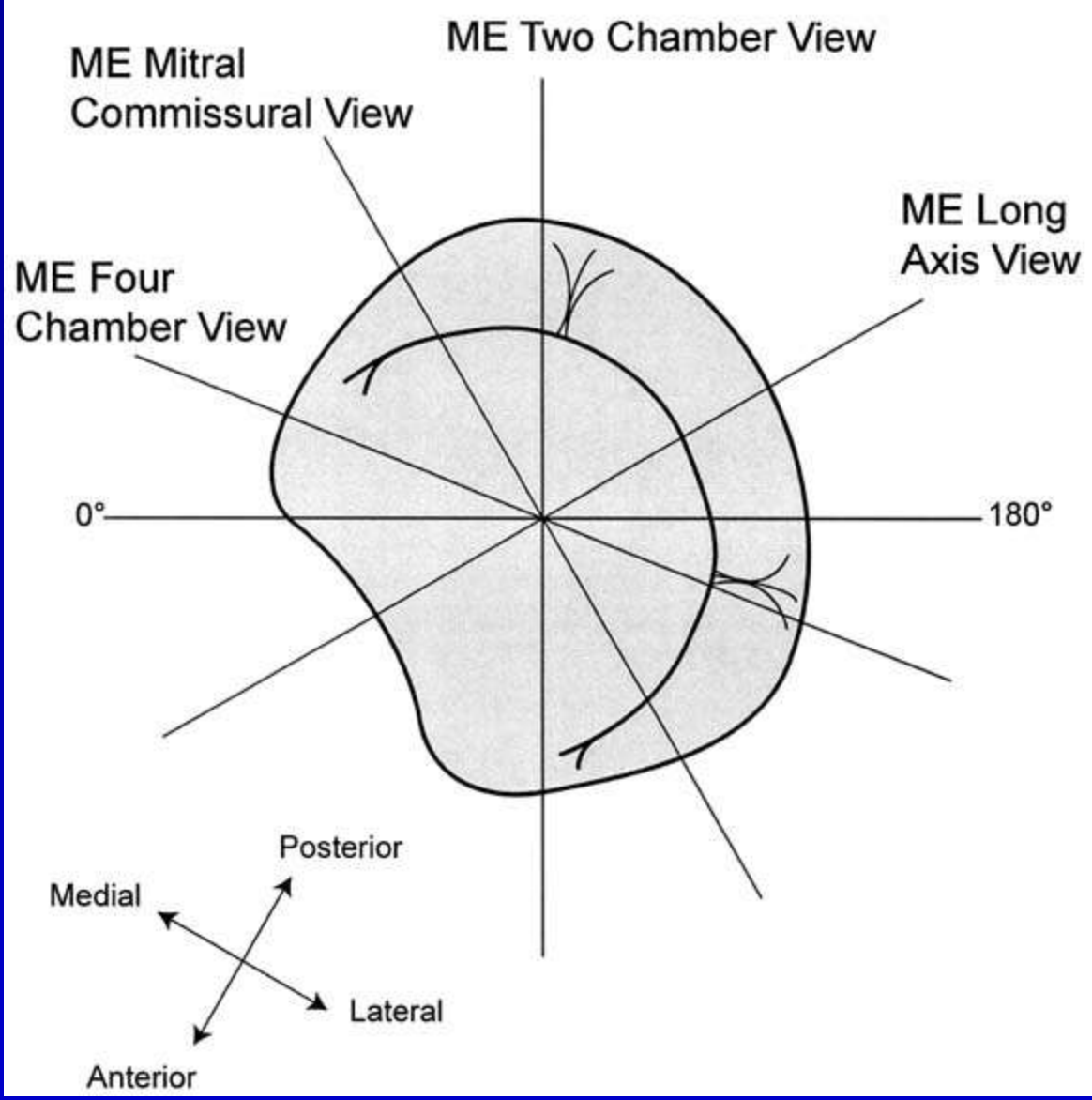
Shanewise JS et al. ASE/SCA Guideline Intraop TEE. J Am Soc Echocardiogr. 1999;12:884

Reference to Mitral Segments



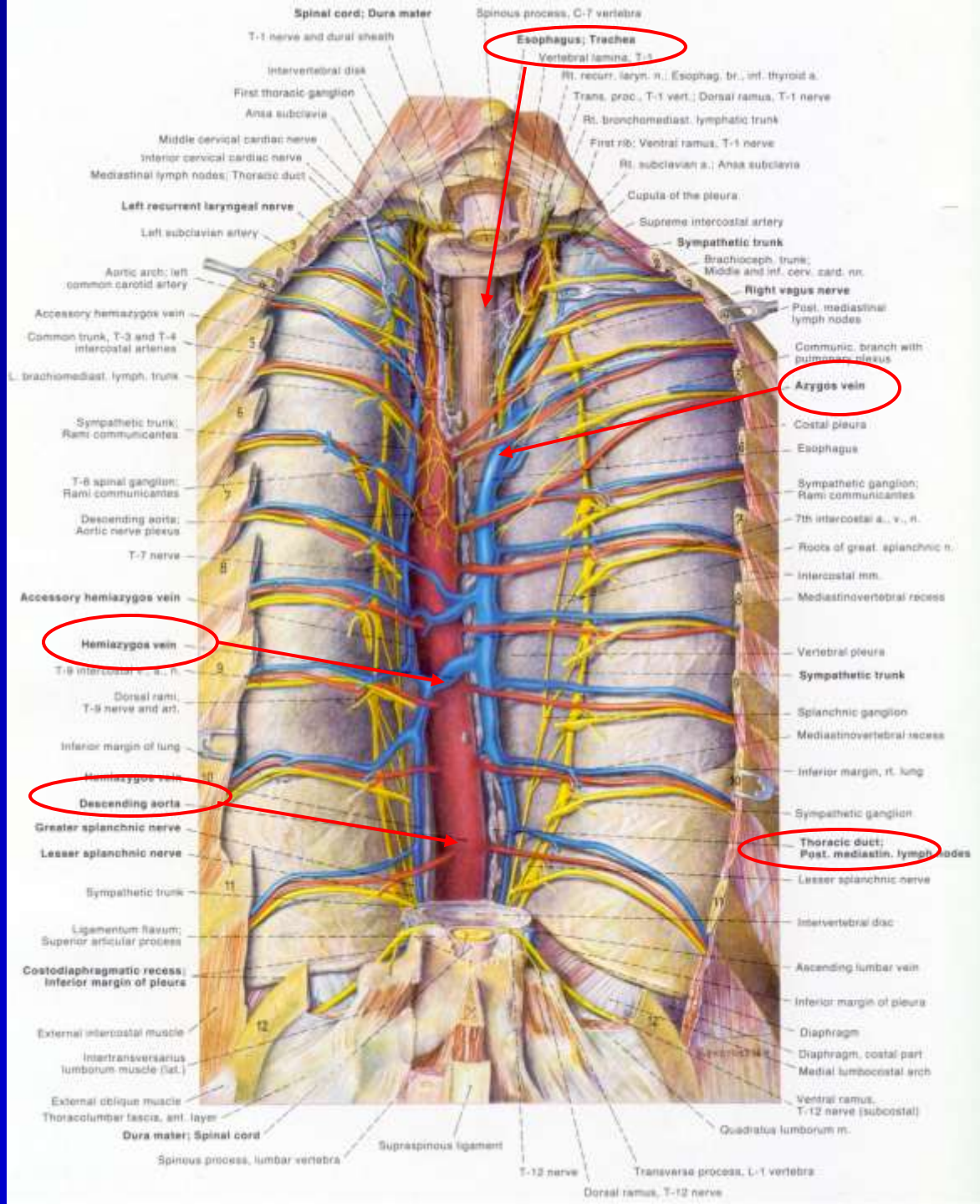
Shanewise JS et al. ASE/SCA Guideline Intraop TEE. J Am Soc Echocardiogr. 1999;12:884

TEE Views in Reference to Mitral Leaflet



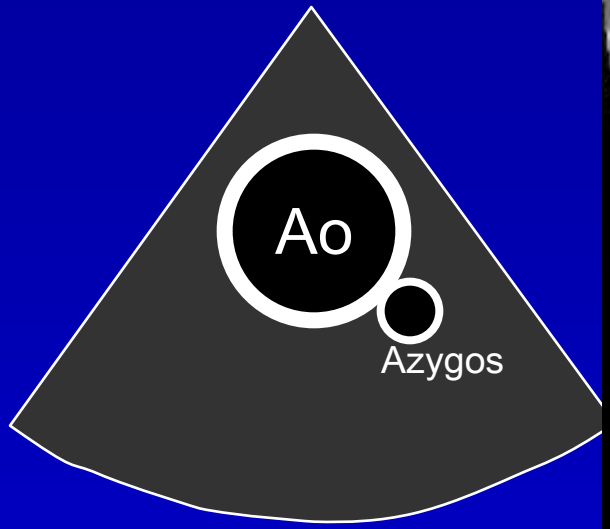
Shanewise JS et al. ASE/SCA Guideline Intraop TEE. J Am Soc Echocardiogr. 1999;12:884

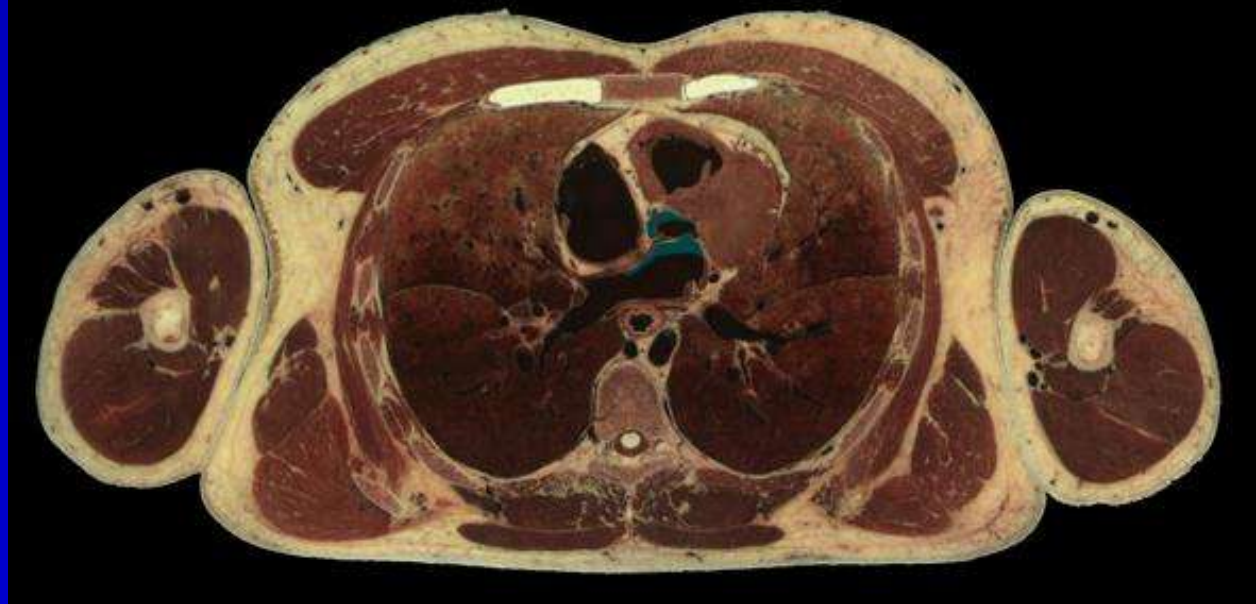
Posterior View of Thorax



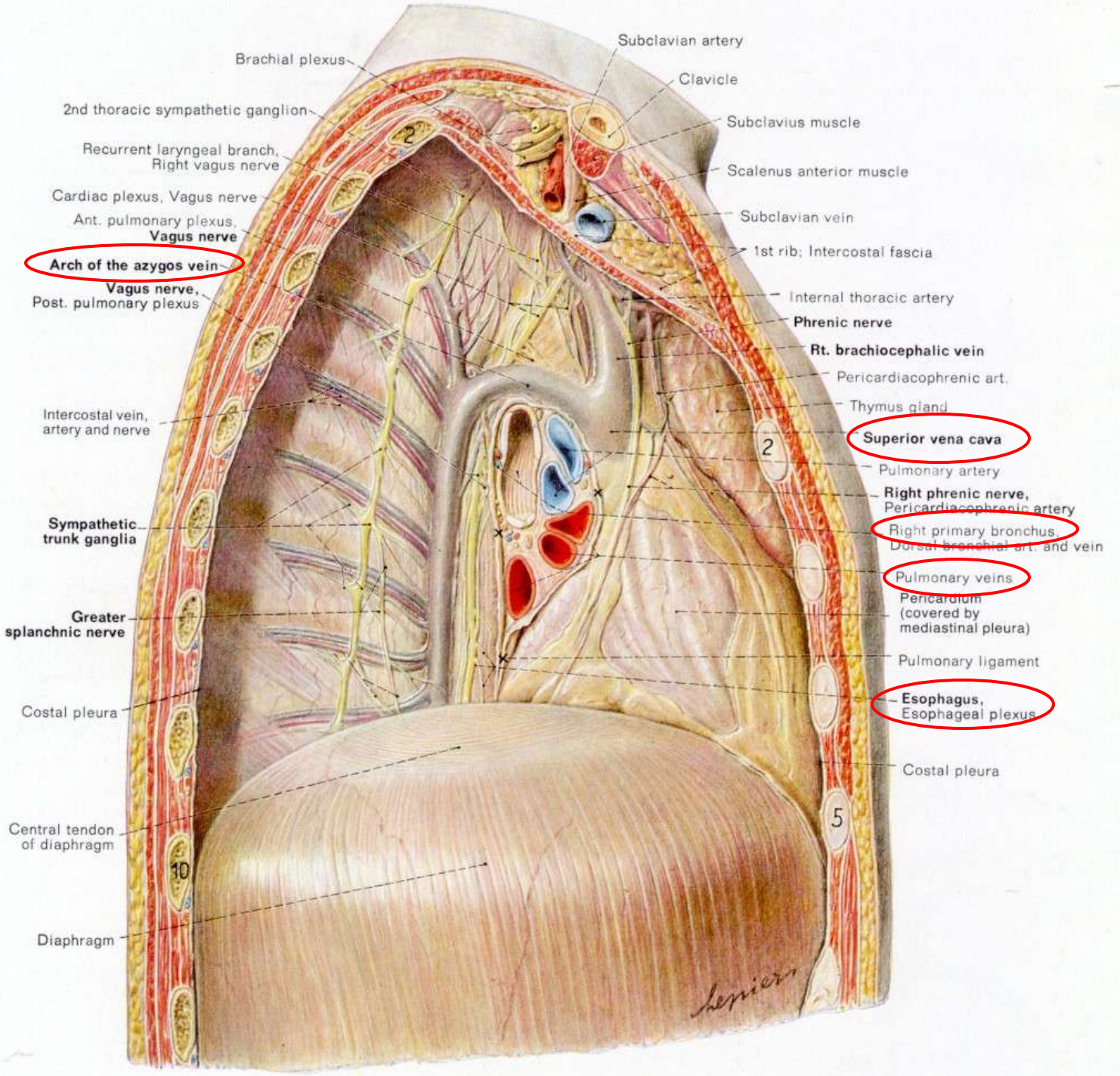
Clemente CD. Anatomy 3rd Ed, 1987, fig 219.

TEE Probe Directed Posteriorly

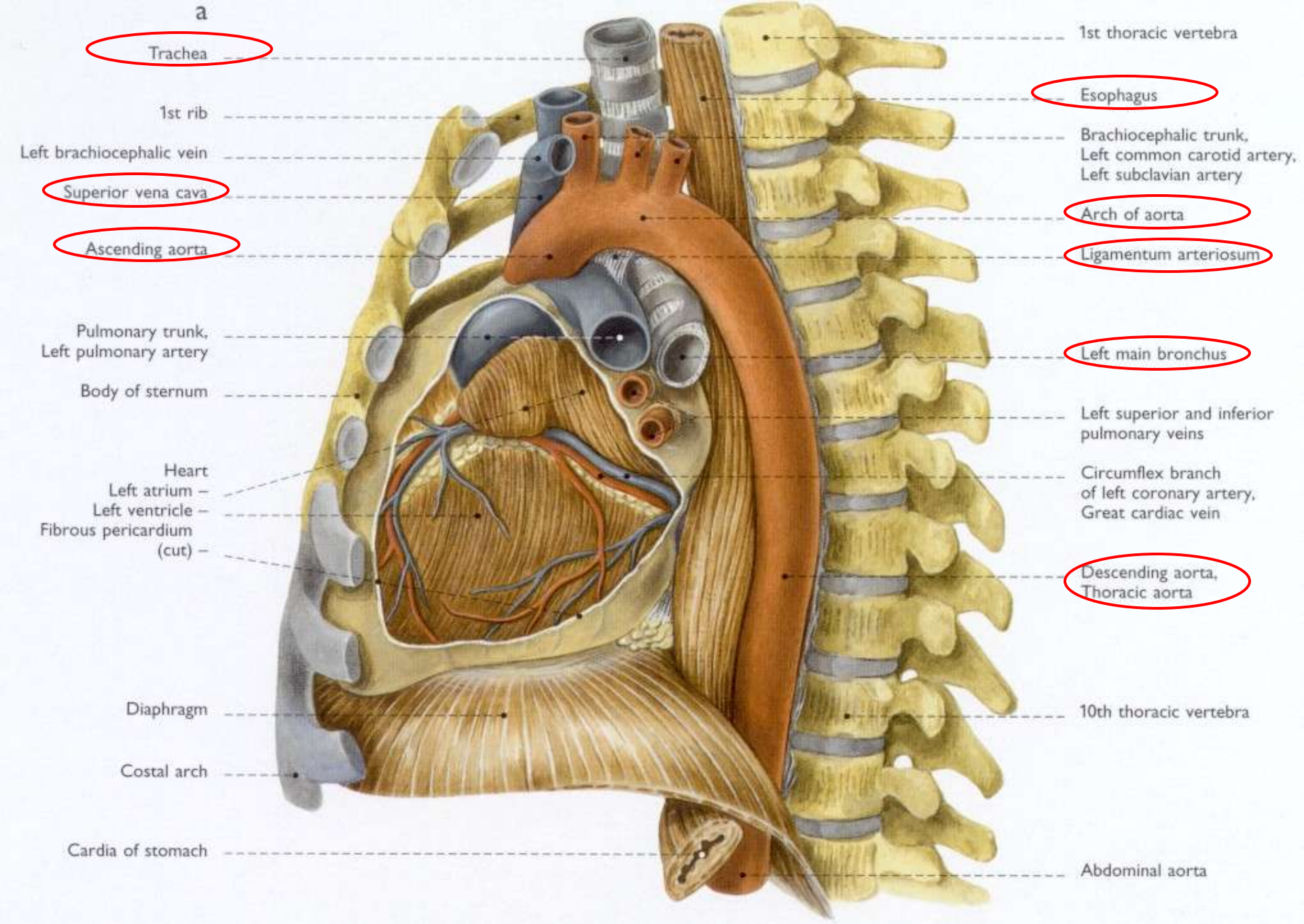




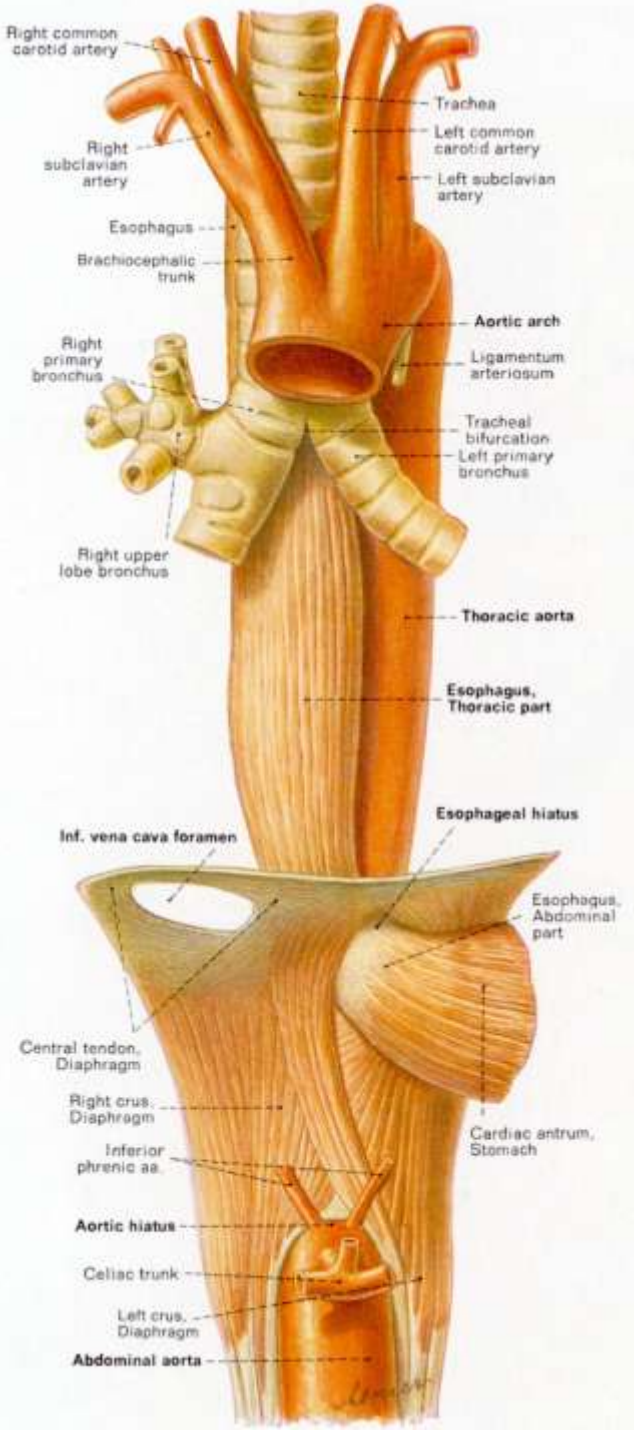
Clemente CD. Anatomy 3rd Ed, 1987, fig 219.



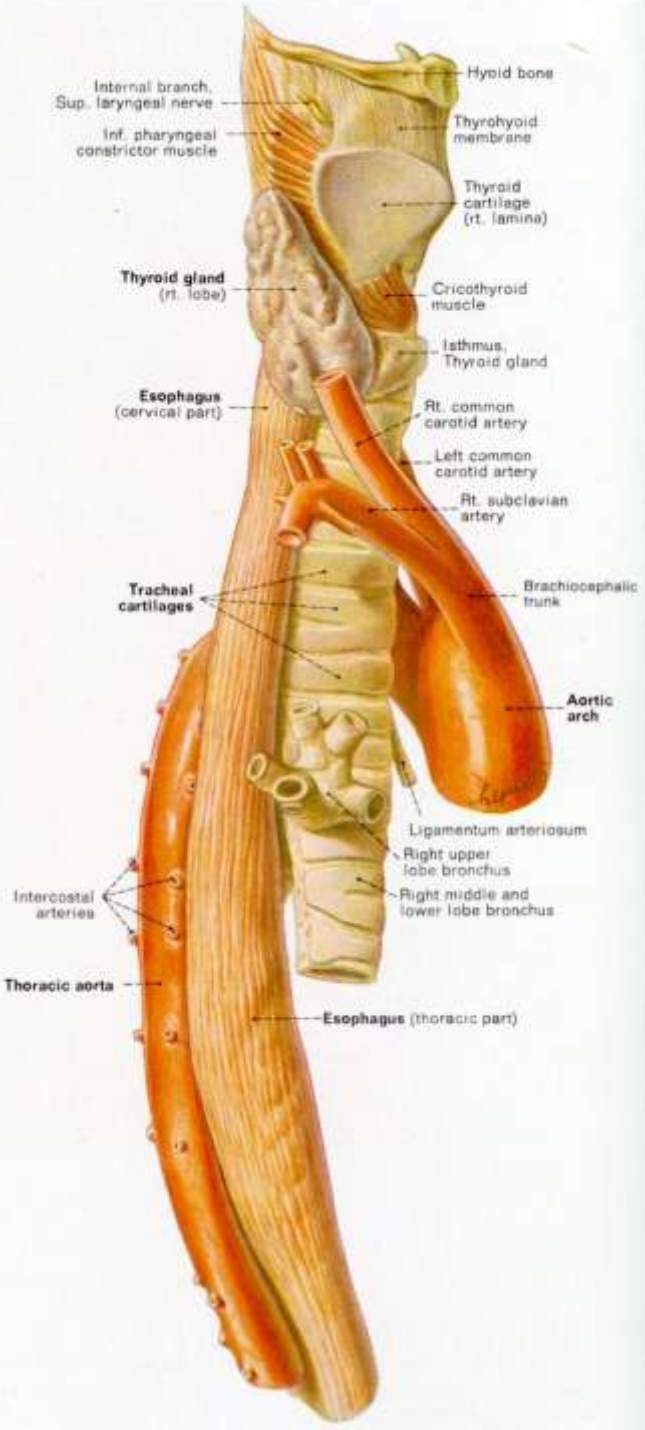
Clemente CD. Anatomy 3rd Ed, 1987, fig 184.

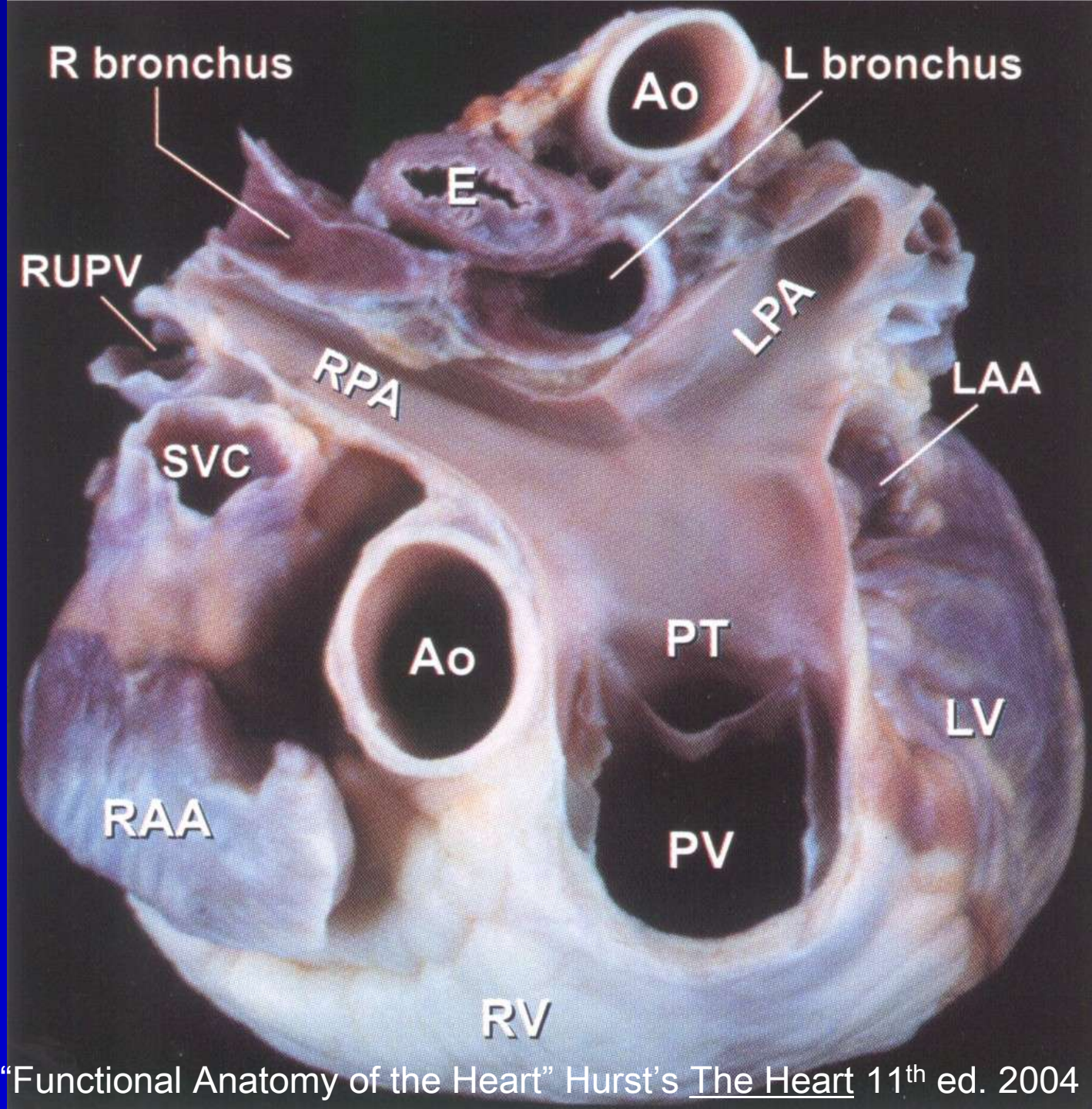

a
Trachea
1st rib
Left brachiocephalic vein
Superior vena cava
Ascending aorta
Pulmonary trunk,
Left pulmonary artery
Body of sternum
Heart
Left atrium –
Left ventricle –
Fibrous pericardium
(cut) –
Diaphragm
Costal arch
Cardia of stomach
1st thoracic vertebra
Esophagus
Brachiocephalic trunk,
Left common carotid artery,
Left subclavian artery
Arch of aorta
Ligamentum arteriosum
Left main bronchus
Left superior and inferior
pulmonary veins
Circumflex branch
of left coronary artery,
Great cardiac vein
Descending aorta,
Thoracic aorta
10th thoracic vertebra
Abdominal aorta

Ref?



Clemente CD. Anatomy 3rd Ed, 1987, fig 216, 7.





Malouf JF et al. Ch. 3, "Functional Anatomy of the Heart" Hurst's The Heart 11th ed. 2004

Mechanical Complications of TEE

- Esophagogastric trauma
- Dental trauma
- Minor oral trauma
- Laryngospasm
- Transient vocal-cord paralysis
- Buckling of probe in esophagus

St. John Sutton MG et al. Atlas of Multiplane Transesophageal Echocardiography, 2003, p. 6-8.

Complications of TEE

- Anesthetic complications
  - Laryngospasm
  - Lidocaine/benzocaine toxicity - methemoglobinemia
  - Respiratory depression, hypoxia
- Physiologic complications
  - Hypertension
  - Arrhythmias
  - Extending of aortic dissection – death
  - Aspiration pneumonia (prior CVA)
  - Myocardial ischemia
- Premature termination due to patient intolerance of probe, about 0.8%

St. John Sutton MG et al. Atlas of Multiplane Transesophageal Echocardiography, 2003, p. 6-8.

TEE Complications, Mayo Clinic Series

• Transient hypertension	0.3%	1/255
• SVT	0.3%	1/294
• Blood-tinged sputum	0.2%	1/425
• Hypoxia	0.3%	1/294
• Transient hypotension	0.3%	1/294
• NSVT	0.2%	1/478
• Laryngospasm	0.14%	1/765
• Heart failure	0.05%	1/1913
• VT	0.02%	1/3827
• Death	0.01%	1/3827
• Miscellaneous	0.8%	1/123

Seward JB et al. J Am Soc Echocardiogr 1992;5:228.

Esophageal Trauma from TEE

- Review of 10,000 TEE's in one institution
- 3 cases of perforation, all after difficult intubation and multiple attempts and resistance to passage
  - Age of patients: 73, 79, 84 … 2 anticoagulated
  - Symptoms occurred 12, 4, and 22 hours after the procedure
  - Symptoms were hemoptysis and mild dyspnea, severe sore throat and subsequent dyspnea and hypoxia, and dyspnea and cough and pain swallowing
  - 2 had subcutaneous emphysema, all had elevated WBC, 2 had drop in Hct, 2 had hypoxia
  - All had surgery: 2 patients failed conservative therapy and required surgery, and the third patient had primary surgery
    - Mucosal tear in the left piriform sinus with abscess
    - Mucosal laceration of cervicoesophageal mucosa
    - Esophageal perforation of cervical esophagus
  - All survived, with prolonged hospitalization of 19-20 days

Min JK et al. J Am Soc Echocardiogr 2005;18:925-29.

Methemoglobinemia

- Topical anesthesia with benzocaine or lidocaine may result in acute toxic methemoglobinemia
- Also can be caused by nitrates (Na nitrate is saltpetre), nitrites, and acetaminophen, and hundreds of other chemicals
- Risk may be increased in patients with G-6-PD deficiency, may be increased in patients on acetaminophen and receiving benzocaine

Otto CM. The Practice of Echocardiography, 2nd ed. 2002; P. 18.
Dougherty AH. Circulation 1995;92:268. Wong DH. Mayo Clin Proc. 1995;70:197.

Methemoglobinemia: $Fe^{++} \rightarrow Fe^{+++}$

Ferrous to ferric

- Hemoglobin is oxidized by the topical agent and is unable to carry oxygen to the tissues
- Usually normal metabolism but it is possible that cytochrome B_5 reductase, methemoglobin reductase, or diaphorase, is overwhelmed, or the hemoglobin is an abnormal M hemoglobin

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Methemoglobinemia: $Fe^{++} \rightarrow Fe^{+++}$

Ferrous to ferric

- pO_2 is normal but oxyhemoglobin level is low
- Cyanosis (total methemoglobin ~1.5 g/dL = 8-12%) and dyspnea
- Pulse oximeter saturation appears only mildly reduced because this technique cannot distinguish well between methemoglobin and reduced hemoglobin
  - It measures red and infrared transmission of light (660 nm and 940 nm respectively
  - methemoglobin (equal absorption at 940 and 660)
  - oxyhemoglobin (more at 940 whereas reduced Hb is more at 660)
  - in high methemoglobin concentration the display will read about 85%
- Diagnosis by ABG with measurement of methemoglobin level at >10% (nl is 0.4-1.5%), symptoms if 30-40% and CNS depression if >50%, usually fatal at >70%

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Methemoglobinemia: $Fe^{++} \rightarrow Fe^{+++}$

- Management: Methylene blue (1-2 mg/kg) as 1% solution (1,000 mg/100 ml) over 5 minutes will result in prompt resolution of cyanosis;
- If patient has G6PD deficiency, methylene blue will not help, and ascorbic acid should be used.
  - Could prescreen African Americans, subjects of Mediterranean discent, southeast Asians
  - Also hyperbaric O2 and/or exchange transfusion have been used

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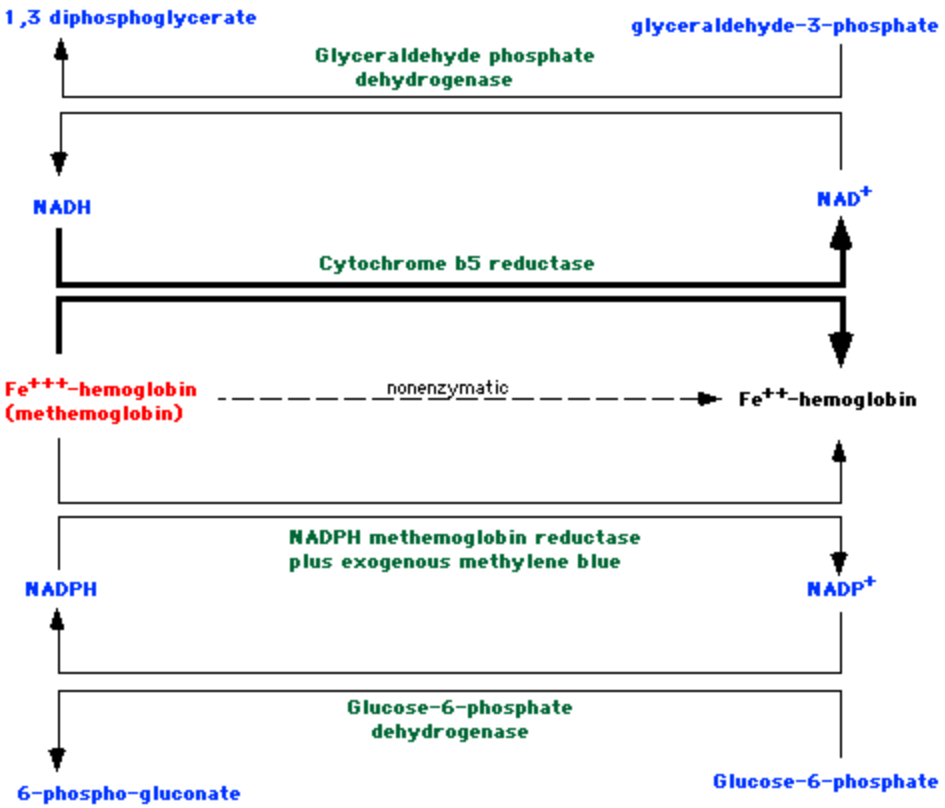
Methemoglobinemia



Metabolic pathways for reduction of methemoglobin The major pathway for methemoglobin reduction is via cytochrome b5 reductase (thick arrows). An alternative pathway, which requires an exogenous electron acceptor such as methylene blue, is via NADPH methemoglobin reductase. Only a small amount of methemoglobin is reduced via nonenzymatic pathways (dashed arrow).

UpToDate; 2005.